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INTRODUCTION

From its inception in 1958, the National Aeronautics and Space Administration (NASA) has sustained an agency-wide commitment to education. During the period December 1993–February 1995, the NASA Office of Space Science (OSS) developed *Partners in Education: A Strategy for Integrating Education and Public Outreach into NASA's Space Science Programs* (1995, referred to as the Strategic Plan). This publication articulated the goals of developing a variety of Education/Public Outreach (E/PO) resources and integrating them with existing efforts to create a coherent vision for education. *Implementing the Office of Space Science Education/Public Outreach Strategy* (developed May 1995–September 1996, referred to as the Implementation Plan) specifically addresses the methods by which the goals articulated in the Strategic Plan can be realized.

EVALUATION

The NASA Office of Space Science contracted with the Program Evaluation and Research Group (PERG) of Lesley University in October 1998 to conduct an external evaluation to determine how effectively OSS is carrying out its E/PO Implementation Plan. The evaluation plan comprises three phases presented in three separate reports. This is an interim report, representing work completed during the pilot period of phase three.

- The first report focused closely on the infrastructure of the OSS E/PO Effort,¹ especially the Support Network (SN), a network of institutions across the nation that help achieve the goals of the OSS E/PO Strategic Plan. This report dealt with variables affecting the SN itself. Thus, the data analyzed were collected primarily from members of the OSS E/PO community. Data were collected between November 1998 and October 1999, and the report was delivered in May 2000.
- The second report focused on the OSS E/PO Effort implementation, beyond the development of the Support Network infrastructure. Data for this report were gathered between January 2000 and May 2001, from both members of the OSS

¹ In this report, we use the term “OSS E/PO Effort” to refer to the individuals and organizations that participate in or contribute to the creation of OSS E/PO material, and all activities carried out in support of the Strategic and Implementation Plans.

E/PO community and the communities it serves directly (educators², scientists, and the rest of NASA). This report focused on the actions of the OSS E/PO Effort to meet the goals outlined in the Strategic and Implementation Plans, the successes of the program, and the challenges that it faced.

- The third report will focus on the impact of OSS E/PO activities on those audiences for whom the products and services are designed (e.g., teachers who participate in OSS teacher training programs, visitors to OSS museum exhibits, etc.). Data sources include the audiences or “end users” as well as those populations involved in the first two reports. Phase three of the evaluation will address the program implementation from October 2001–August 2003. The final phase three report will be delivered in winter 2003.

THIS REPORT

This report discusses preliminary findings for the OSS E/PO Effort implementation during the period of October 2001–June 2002. The evaluation efforts of this period were devoted to piloting evaluation protocols and methods to ensure both breadth and depth to the findings for phase three. The data supported formative evaluation feedback to the OSS E/PO community in the form of recommendations for strengthening the program as it moves forward. Although the primary focus of this report is impact, it also revisits the themes of the first two reports: infrastructure and implementation, as these also help determine the impact of the OSS E/PO Effort.

The data presented in this report are primarily *qualitative*. Qualitative data allow for deep exploration of a variety of areas, including many that are uncovered during the data collection process. Analysis of qualitative data can uncover ideas, beliefs, attitudes, challenges, etc. that are present in the population of interest. Unlike quantitative analysis, qualitative analysis cannot be used to estimate the prevalence of any specific variable, because the data are not representative of the larger population beyond the participating sample. Thus, while our analysis can reveal, for example, beliefs that some scientists hold about education, our analysis *cannot* give any indication of *what proportion* of scientists hold a specific belief.

Throughout the report, there are citations from the data. They are not attributed to specific settings and speakers; rather, they are included to add context and richness to the discussions and to illustrate the perspectives of those engaged in the work. All data cited in the report have been selected to *represent the themes and trends* that emerged from the data and are characteristic of the *perspectives voiced by multiple respondents* and issues

² In this report, we use the term “educator” to refer to any individual or organization that is responsible for disseminating information to a larger audience. This includes (but is not limited to) classroom teachers, museum staff, librarians, Girl Scout leaders, speakers presenting to the public, etc.

related to the program during the report period. They do not indicate that each individual (or a majority of individuals) in the total community beyond the sample group shares the same perspectives.

PARTICIPANT AUDIENCES

For this report, we gathered data from a wide range of individuals whose comments, ideas, and concerns are reflected in the report. These people include:

- Members of the OSS Education Council—including the SN, as well as OSS E/PO administration, and staff from NASA’s Code FE (Education) and Code EU (Minority Universities)
- OSS E/PO personnel—including staff working on E/PO within OSS missions, E/PO developers associated with OSS research projects, and others playing important roles in the creation of OSS E/PO
- NASA Education Division (Code FE) staff
- Scientists—mission scientists, research scientists, and discipline scientists; scientists interviewed include NASA civil servants, employees of organizations working with NASA, and university professors, among others
- Formal and informal education personnel—K–12 teachers, museum staff, librarians, and others engaged in the process of educating the public
- Other OSS E/PO partners—publicly and privately funded organizations and individuals who have worked with OSS personnel to create space science education resources
- Volunteers—current and former space scientists, as well as amateurs with knowledge of and interest in sharing space science information
- Space science education providers beyond OSS—publicly and privately funded organizations and individuals who have created space science education resources without input from OSS personnel (Note: at the time of the preparation of the interim report, data from this audience have not been collected)

The individuals interviewed formally and informally are described in Table 1 on the following page.³

³ Many participants fall into more than one category. In general, they were counted in the role that was most relevant to their OSS E/PO work. In particular, participants were only classified as “OSS E/PO Partners” or “Non-NASA E/PO Providers” if they did not belong in any other category.

TABLE 1: PARTICIPANT AUDIENCES

Audience	Formal Conversations	Informal Conversations (Approximate)	Total (Approximate)
Ed Council	3	50	53
OSS E/PO	0	30	30
Code FE	1	5	5
Scientists	25	20	45
Formal Educators	48	35	83
Informal Educators	13	12	50
OSS E/PO Partners	2	10	12
Volunteers	22	3	25
Non-OSS Ed Providers	0	0	0
Total	113	165	278

Note: The final report will reflect data collected from a wider sample of individuals. Some audience groups are underrepresented at this time; this is usual with Interim Reports.

EVALUATION METHODS

Evaluators conducted formal interviews with a range of individuals who have interacted with or been affected by the OSS E/PO Effort in various ways (see list above). Interviews have taken place in person or by phone. In many cases, follow-up phone conversations or e-mail exchanges have supplemented the interviews. Evaluators have maintained communication with Education Council members (including the Director and administrative staff), by attending Education Council meetings, observing the plenary sessions and selected Working Group meetings, and providing formative evaluation on an ongoing basis.

Evaluators attended a variety of events hosted by the SN and/or its component institutions including conferences, workshops, teacher trainings, and the first OSS Education conference. Evaluators also sat in on classrooms and workshops that utilized OSS E/PO resources. At these events, evaluators observed interactions, interviewed participants, and provided formative feedback as appropriate.

Evaluators also attended a variety of scientific and educational conferences with a strong OSS E/PO presence. At these conferences, evaluators observed OSS presentations, interviewed or surveyed conference attendees, and engaged participants in informal discussions on topics relevant to the evaluation.

In addition, evaluators have visited all of the SN institutions; reviewed a range of OSS documents, including the Strategic and Implementation Plans, internal and external newsletters, the 2000 Annual Report, and Space Science Education Resource Directory (SSERD); and have participated in teleconferences. Throughout the evaluation process, evaluators have exchanged phone calls, e-mail, and memos with staff about a range of issues, activities, and events.

PROJECT DESCRIPTION

The OSS E/PO Effort is dedicated to realizing the goals of the Implementation Plan, which was developed with the mission of making “education at all levels and the enhancement of public understanding of science integral parts of space science research activities.”⁴ The intent was to build a bridge between OSS and the public, particularly the formal and informal educational communities. The goals of the Effort are outlined in the current OSS Strategic Plan:⁵

- To share the excitement of space science discoveries with the public
- To enhance the quality of science, mathematics, and technology education, particularly at the pre-college level
- To help create our 21st century scientific and technical workforce

Virtually all OSS E/PO is funded through OSS missions and instrument programs,⁶ through grants for Supporting Research and Technology⁷, and through the activities of

⁴ *Partners in Education: A Strategy for Integrating Education and Public Outreach into NASA's Space Science Programs*, 1995, p.1.

⁵ *The Space Science Enterprise Strategic Plan*, 2000 (p. 23). Note that the original implementation plan had four goals, which have been reframed into the current goals as a result of input from the larger space science and educational communities.

⁶ Missions and instrument programs are large-scale, long-term research projects. The funding process for missions and programs utilizes Announcements of Opportunity (AOs). The OSS E/PO Effort has mandated that all new missions and programs allocate 1–2% of their budget for education and public outreach. Older missions, such as Voyager, are exempt from this mandate, although many do support some type of E/PO development.

⁷ Grants for Supporting Research and Technology are smaller grants, covering relatively small, short-term research projects, generally associated with an existing mission. The funding process utilizes NASA Research

the SN.⁸ OSS guidelines require that scientific staff be involved with the development of E/PO related to their missions and research. Scientific staff are often supported by personnel dedicated specifically to development of E/PO resources.

One of the main actions of the OSS E/PO Effort was the development of a Support Network (SN) comprising four Forums and seven Broker/Facilitators (B/Fs). The Forums correspond to OSS's four themes (Solar System Exploration, Sun-Earth Connection, Structure and Evolution of the Universe, and Astronomical Search for Origins). As every OSS mission is aligned with one of the themes, the Forums reach every OSS mission. The B/Fs are spread across the nation; they were originally conceived as working regionally with users of OSS's educational products and identifying the needs of the populations served by the OSS E/PO Effort. The Forums and B/Fs (the SN), together with personnel from OSS (Code S), NASA's Education Division (Code FE),⁹ and the Minority University Research and Education Division (Code EU), form the basis of the OSS Education Council—the group created by OSS to ensure coordination of E/PO efforts and carry out a variety of critical OSS-wide support activities. The OSS Education Council has met regularly to share information and experience and to develop the continuing activities of the OSS E/PO Effort.

The SN has provided a variety of useful services since its inception; many of these are highlighted in the first two reports¹⁰. As a consequence of SN activity, the OSS E/PO Effort as a whole has increased in connectivity and integration. During the period covered by this report, the system was engaged in a variety of activities. The SN and its components continued and expanded the work it had been involved with over the previous years, including outreach to the educational and scientific communities, development and implementation of educational resources and systems, refining the SN infrastructure, and coordinating actions with NASA's Code FE.

Recent activities of the OSS E/PO Effort have included efforts to reach more people across a wider range of audiences. E/PO leads, SN staff, and mission and research scientists have increased their distribution of materials, the scope and content of workshops, and other interactive experiences. The opportunities for interactive

Announcements (NRAs), and grants submitted in response to NRAs are not required to include funds for E/PO. While educational components are not mandated for Supporting Research, scientists working on Supporting Research are encouraged to develop E/PO resources in conjunction with the scientific content of the grants.

⁸ There are a few smaller grants programs, such as IDEAS, that provide E/PO funding that is not tied to specific NASA missions or Supporting Research. These represent a very small proportion of the OSS E/PO budget. In addition, Guest Observer Grants (which support guest scientists on missions) may involve E/PO components.

⁹ NASA's educational program is currently undergoing restructuring, and Code FE has been subsumed by the new Code N. It is hoped that the coordination and collaboration that existed between the OSS E/PO Effort and NASA Education will continue and increase.

¹⁰ Available by request from Dan Woods (dwoods@hq.nasa.gov).

experiences occurred at schools and other community locations, museums, space science organizations, conferences, and myriad other sites. In addition, the space science community codified, catalogued, refined, and created an expanded range of products for their audiences, disseminating them through the Web where possible and in hard copy form for multiple groups including classrooms, libraries, museums, and science centers. The Space Science Education Resource Directory (SSERD) was completed and made accessible to the public through the Web site <http://teachspacescience.stsci.edu>.

The Education Council meeting agendas have been modified to include a range of interactive activities and professional development (PD) opportunities for its members. The agendas have also included expanded opportunities to dialogue directly with members of Code FE as well as other groups such as the minority professional organizations and other NASA Enterprises.

Perhaps most significantly, the OSS E/PO Support Network convened a conference in Chicago in June 2002, which was dedicated to a three-day discussion about how to create effective space science and education partnerships to further the goals of the OSS E/PO Effort. Participants included scientists and other personnel from OSS and across NASA; representatives from a number of formal and informal education organizations; members of a range of minority professional organizations; and education and research faculty from a range of colleges and universities across the country. The conference fostered extensive dialogue about the range of interests, resources, issues, and conditions for each population that create both opportunities and challenges to partnerships and collaborations for all participating communities. Unanimously acknowledged by all participants as a benchmark event in space science education, the conference initiated a national conversation that has implications for future undertakings and accomplishments.

FINDINGS

GROWTH AND EXPANSION

OSS E/PO resources have been growing in number and diversity since the implementation of the current E/PO Effort. This growth has been documented in the OSS Annual Report, regular newsletters, and through NASA's own EDCATS¹¹ system.

OSS has supported the creation of a vast array of classroom activities, image-based products (such as posters and litho sets), teacher workshops, museum exhibits, planetarium shows, public presentations, public installations, and other products and events that serve to share space science findings with schools, museums, and the general public.

There's no question that space science education is being enhanced. More money and energy is being thrown at it than ever before. (Scientist)

I was surprised at the number of educational programming options that NASA had put together. (Education conference participant)

Data indicate that the reach of the OSS E/PO Effort has expanded to include groups of learners who have not previously benefited from NASA's educational resources. Resources have been developed to address the needs of audiences of varying ethnicities, of all ages, in all areas of the country, and at various levels of physical and intellectual development.

To increase the visibility of space science in minority institutions, OSS has worked with MURED¹² to create NASA's first Minority University Initiative (MUI). The MUI focuses on bringing space science opportunities to students and faculty at minority institutions. One requirement for MUI funding is that the MUI form partnerships with NASA centers, research facilities, and/or research universities. This has started the process of integrating students and faculty from minority institutions into the mainstream of space science research. Several of the programs funded by the MUI include outreach into the K–12 community, either through preservice or inservice teacher education or

¹¹ Education Division Computer-Aided Tracking System, a NASA-wide database of education activity.

¹² Minority University Research and Education Division.

through programs that directly involve K–12 students. These activities directly address OSS’s educational goal of creating the 21st century scientific and technical workforce.

It’s a hugely difficult nut to crack. Every place has different challenges. The challenge is that there’s no single solution. The main thing is to support innovation in this regard. (Scientist)

NASA is clearly the leader amongst federal agencies in having a real, true, demonstrated interest in trying to expand the scope of schools that are involved with NASA programs. (Professor)

OSS has also been building relationships with scientists who are members of Minority Professional Organizations. Minority scientists and researchers reported that their connection to OSS provides them with tools they need to act as role models in their communities and mentors to their students and colleagues.

Being a speaker in the community, I’m able to go out to community activities and raise awareness. I’m African-American and I find myself a spokesperson to raise the awareness of our students. (Volunteer)

OSS provides support for the development of resources for the differently-abled and for non-English speakers. Other new materials and educational programs have been designed to align with Native American traditions, reaching audiences that have not been served by OSS E/PO in the past. The OSS E/PO Effort has also expanded the age range for which it creates resources. OSS E/PO resources now include those that are suitable for younger learners.

They are now producing materials for younger children. That was a limitation before. They don’t dumb it down; they keep the content. But now they can actually use it and read it themselves. (Teacher)

The OSS E/PO Effort disseminates resources to learners in a variety of settings. For example, the SUNBEAMS program and the Chicago Urban Initiative target urban schools, and resources such as the Solar System on the Mall bring space science to an inner-city audience. The OSS E/PO Effort also utilizes existing networks such as libraries, small museums, and science centers to reach rural areas.

I think it’s a wonderful way to excite the kids and open up their minds to other possibilities. This is a rural area, and kids don’t go towards this type of science field. (Librarian)

Educators in both rural and urban areas said that they benefit from the development of resources that are inexpensive to acquire and to use.

It made me more cognizant of what NASA had to offer with reference materials—I didn't realize how much you could request for free. (Librarian)

MERITS OF OSS RESOURCES

In general, data from the contacted audience groups are extremely positive. Individuals consistently report that they (and those they are educating) find space science exciting, engaging, and complex; this indicates that OSS is succeeding in its first goal of sharing the excitement of space science. Teachers and museum staff observe that space science sparks children's interest more than any other scientific subject, with the possible exceptions of robots and dinosaurs. Resources and activities that feature space science engage students and give them the motivation to learn scientific concepts in ways that less dramatic topic areas might not.

It increased [students'] knowledge and their yearning to learn. It really sparks their interest to learn more about space stuff. (Teacher)

[Kids] are so excited to learn about the solar system and I ask questions during the lecture—"Who wants to be an astronaut or travel to Mars?"—and they jump up in the air, they are so excited. Hopefully, some will continue and direct their careers in science and in space. (Volunteer lecturer)

Educators commented that because NASA is a recognized name, it adds credibility to resources; the NASA brand gives them confidence in the product. In addition, if they use NASA materials, they reported that their own audiences have more confidence in *them*. There is a halo effect that extends from the resource to the teacher, museum, or lecturer using the product that makes the educator more credible in the eyes of their own audience. Teachers said that having a visitor "from NASA" is a great way to catch students' attention because the visitor is seen as an expert. Volunteers giving lectures to the public note that materials with the NASA logo on them are seen as high quality, and that lecturers who use such materials are assumed to be high quality, as well.

Suddenly we have access to a big name in the news. We've heard about it and now it's available right here on our home ground. [People] appreciate the fact that some NASA staff came to our community. (Librarian)

It gives us a lot of credibility that has already benefited us when talking with senators and funders. That means a lot and will continue to mean a lot. (Museum administrator)

USER CHALLENGES

The OSS Implementation Plan specifically states that resource development “starts with the identification of a user need” (p. 3). Limited interaction between users and resource developers can make identification of user needs difficult. In addition, developers may not understand the constraints faced by users. Educators, especially those working in formal K–12 education, reported that they have difficulties fully utilizing resources that are developed without consideration of such factors as:

- The current focus on standards
- Limited access to computers and other technology
- Limited classroom time for space science
- Limited physical space in classrooms, museums, libraries, and other venues for which OSS is developing resources
- Limited teacher understanding of space science content

Scientists and E/PO developers have indicated that mission needs can override other considerations when resources are developed.

There’s a very large tension between PR and education. Would you give up having the initial letters of your mission [on a resource] to have a profound difference on elementary level?
(Scientist)

The result is that many of the resources focus on mission content without sufficient attention to how the resource can be integrated into K–12 curriculum or be utilized by teachers with little familiarity with space science content. K–12 teachers express a need for resources that support the benchmarks and standards on which their students are tested.

STANDARDS

The OSS E/PO community recognizes that the national science standards and standardized tests are driving curriculum and pedagogic decisions nationwide. The current emphasis on education standards and accountability has increased the urgency of user needs and has more strictly defined the types of resources that meet these needs. This issue is particularly salient for classroom teachers, but is becoming more pressing for informal venues as well.

The OSS E/PO Effort, in conjunction with NASA Education, has developed a “standards quilt,” a tool that links previously developed space science resources to national standards. Formal educators have indicated appreciation for the quilt approach to guiding

them to select resources that conform to the standards, recognizing its value and noting that it is a step in the right direction. Many of the teachers interviewed expressed a concern about the quilt's accuracy, noting that it assigns standards labels to resources that may have been developed without reference to the standards.

There needs to be substance behind the standard. Now what happens is that they develop some resource and say "Hey, it's energy—that's a standard," rather than looking at the standard and seeing what needs to be covered and then create an activity that meets that need. (Teacher)

Identifying the correspondence between the resource and the standard is not enough for teachers to select it for their classroom. Teachers indicated that the resources need to be immediately adaptable to the curriculum they are using to be useful. Because teachers are constrained by the standards, materials need to integrate with existing standards-aligned curricula. Given the limited amount of time available to teach science during the school year, teachers said that resources that support other topic standards are easier to incorporate into their classrooms.

You need to talk about the integration of science with other subjects. And the hook science has for capturing and maintaining student interest. It can promote literacy and math skills. (Volunteer lecturer)

PEDAGOGY

As recommended in the Implementation Plan, OSS is beginning to develop classroom activities and museum exhibits such as *Cosmic Questions* that use hands-on, inquiry-based methods, encouraging learners to raise questions about space science and develop scientific methods to answer these questions. Current research indicates that providing resources that allow for collaborative, inquiry-based work, as well as those that provide factual information in a more didactic manner, make space science concepts accessible to a wider range of learners than are reached with strictly descriptive materials. Classroom teachers, in particular, reported that they are finding more OSS E/PO resources that meet their needs for hand-on, inquiry-based materials.

I have not been to one NASA activity in the past five years that did not include some type of hands-on thing to do in the classroom. They always include that, so they are always relevant. (Teacher)

Formal and informal educators acknowledge that many OSS E/PO resources present learners with a range of compelling, accurate, up-to-date information. They have observed that the information is not necessarily presented in a way that allows students to synthesize it with their existing knowledge. Current educational research suggests students are generally better served if they are allowed to develop hypotheses, test them, and find connections to things they already know and understand.

You need to go beyond the “Ooh aah” and take advantage of the kids’ enthusiasm to get some real information in there.
(Teacher)

The difficulty is when you sit down and say, “What did they actually learn and does that have to do with what we would really like them to know? Do they learn to think critically? Learn how to build a logical argument?” which is what we want them to do.
(Scientist)

LOGISTICS

NASA is on the cutting edge of much technology and has utilized new media in a variety of ways. It is usually well ahead of the public sector technology capacity, in particular formal education and local public facilities, including libraries. Evaluation data have consistently documented the lack of technology consistency that exists within the many settings the OSS E/PO reaches. Many schools, libraries, and small science museums have limited technological capabilities and cannot make use of electronic resources, especially those that rely on fast equipment, high-speed Web connections, and sophisticated users. Many educators are new to computers and to the Internet, and need support to use the Web pages and CD-ROMs that the OSS E/PO Effort develops.

We are so busy trying to leverage ourselves that we forget why we are there in the first place. Maybe the teacher needs us to set up their Netscape and help them use Google, which they don’t know about, to find things. Instead, we are saying, for the first class, you will show them this picture, use this exercise, and demo this concept.
(Scientist)

Data indicate that many schools, libraries, and small museums have limited time and space. Complex, time-consuming activities or curriculum units are beyond the physical limitations of some of the OSS E/PO Effort’s intended audiences.

The experiment with the asteroids with the dry ice was interesting, but we don’t have room to make asteroids here.
(Librarian)

Realistically, you have fifteen hours a year for science—what can you put in there that would build a strong foundation. But you can sneak in more time if you can find the linkages to math and reading.
(Teacher)

COMMUNICATION

The Space Science Education Resource Directory

One of the achievements of the OSS E/PO Effort is the development of the Space Science Education Resource Directory (SSERD). The SSERD is a searchable online directory of electronic OSS E/PO resources. The OSS E/PO staff responsible for its development have worked consistently to create and improve this education resource. Collecting

feedback from teachers at conferences and within their own organizations, they shaped the directory to address a range of teachers' information needs.

Teachers interviewed during this evaluation period, none of whom participated in its development, shared a number of reactions that suggest there is a need to communicate more effectively outside of the space science community about the directory's availability. Many educators are simply unaware of the SSERD. Many of the teachers interviewed said they would appreciate a database similar to the SSERD, but did not know that one already existed. Others reported that they had heard of the SSERD, but were unable to find it online.

Some of those who have located and used the directory said that they were unable to search on variables beyond grade, subject, and topic. Teachers said they need to be able to search for materials that are related to specific standards, for activities that require little time, for activities that can be inserted into existing curricula, and for materials that can be purchased or created for little money.

I went to the site from the class, but I couldn't find the materials I wanted there. I didn't spend a lot of time on it. (Librarian)

Other Web Sites

Users who are not using the SSERD reported that to find a particular resource, they must identify the mission that funded it, find that mission's Web site, and navigate through the mission pages to find the resource. Educators who want to find OSS resources that address particular topics or meet certain standards reported that it is time- and energy-consuming to search the NASA Web site to find resources that meet their needs.

It's a big Web site with lots of stuff. Sometimes I get lost in there for hours, going from place to place, and then I don't remember why I went there. (Teacher)

The Web is a fantastic resource, but it's a passive resource. So, the people who are actively searching for things can find them. (Museum staff)

Non-Web-based Communication

Those who work with the OSS E/PO system (educators, scientists, and volunteers) reported a strong need for a personal connection (see also the discussion on this topic on page 19). These individuals reported that finding a person to connect with can be challenging.

It depends on how much initiative you take—It takes time to track people down, but if you make the effort to make personal contacts, they are more than happy to help you. But you have to get personally in touch. (Volunteer)

Several educators offered the suggestion that their needs would be better met if OSS contacted them directly about workshops, programs, and resources that are available to them.

I think more publicity would be helpful. I happen to be aware of this [program] because of a summer program that introduced it to me. Connecting to the school districts and the science chairpeople who could dispense information down to the teachers would be helpful. (Teacher)

I would not have known about this if I had not heard about it through the grapevine. I'm not sure there was much coverage about it in the paper. It's important that they create an awareness of the program and that would be beneficial. (Librarian)

I think there are ways to get the word out better. Sending letters to department chairs of science faculty at minority institutions, because not everyone is on the OSS listserv. (MUI recipient)

Teachers have suggested that OSS advertise in the NSTA (National Science Teachers' Association) quarterly newspaper *Science & Children*. While OSS resources are occasionally written up in *Science & Children*, there is not enough information for teachers to obtain resources or replicate activities described in the publication. The American Federation of Teachers (AFT), the National Education Association (NEA), and the Association for Supervision and Curriculum Development (ASCD) publish newsletters and periodicals whose readers have reported that they are not targeted by the OSS E/PO Effort. Teachers also suggest that NASA and OSS have a bigger presence at regional and national conferences, since travel expenses prevent many educators from traveling beyond their home region.

EXPANDING CAPABILITY

Teachers, librarians, and museum employees said that they are hungry for space science materials that will intrigue and educate students and visitors. In order to make the most of these materials, educators need support and professional development to help them understand both the content of the materials and the best educational practices for delivering that content.

EDUCATOR PROFESSIONAL DEVELOPMENT

Educators, especially those who lack prior knowledge of and comfort with scientific theory and content, said they face significant challenges in understanding and using some OSS materials. Teachers, librarians, community leaders, and staff at small museums said they need additional support and training to be able to make the best use of space science

resources. Several programs within OSS, such as SUNBEAMS and Amazing Space, have tried to meet this need by offering opportunities for teachers to work closely with scientists and space science educators for an extended period of time, often maintaining relationships with these teachers for several years. Teachers involved in these programs said that they increase their understanding of science and scientific pedagogy, as well as become more confident about their ability to teach the material. Furthermore, these teachers provide direct feedback to the system about what type of resources work in the classroom, and what needs are currently unmet. These workshops have a deep impact on the teachers who are involved with them, but reach a relatively small number of educators.

To expand the reach of the OSS E/PO Effort, OSS has increased its presence at national educational conferences, presenting short workshops to support the use of new resources. OSS also offers short teacher workshops in conjunction with some traveling museum exhibits, and offers workshops to librarians, Girl Scout leaders, and others who have the opportunity to reach an audience of learners. Educators who attended OSS workshops found them interesting and said that they learned from them.

They had a lot of stuff and they organized it well. The workshop was time well spent for me. (Teacher)

Most of us were very pleased with the presentation of the workshop, [they] didn't make us feel dumb or inadequate; we were amazed at some of the things. (Librarian)

Some educators, especially those who have little pre-existing space science knowledge, reported that one-time programs don't give them the tools they need to have an impact with learners. They need substantial PD in the form of ongoing support and communication with both experts and other educators.

I could have used more training. I needed some more background information to make it more teacher-friendly for me. (Teacher)

The need for ongoing support is especially important when bringing space science to populations that have not traditionally been responsible for science learning, such as librarians and scout leaders. These audiences said they face challenges implementing activities or resources presented in a single workshop session.

I know that those of us who attended enjoyed the workshop, thought that it was very beneficial, even though we didn't know how we were going to implement it. (Librarian)

I have not been able to utilize this information I learned since the workshop. (Librarian)

DEVELOPER PROFESSIONAL DEVELOPMENT

The OSS E/PO Effort has mandated E/PO for all missions, supported space science E/PO beyond missions, linked OSS E/PO with the world of education-related organizations, and created opportunities for a broad section of the space science and E/PO development communities to learn about the needs of users and to identify areas where they could make a contribution. Because of these and other OSS activities, there are individuals who are approaching space science education for the first time who may lack the experience and knowledge needed to make meaningful contributions.

When you come at it initially, it's very difficult to get into the community in an active sense, but once you're in, it's much easier. (Scientist)

Each of the educational Forums includes staff members who are, or have been, professional educators; these staff members provide support and expertise to resource developers across the OSS E/PO Effort. In addition, OSS provides some PD opportunities (such as the Scientist Training workshops at SSI) for scientists and resource developers. Data across the OSS E/PO community indicate that these opportunities serve a relatively small subset of the community. Less experienced resource developers reported that they would benefit from a coherent training and support framework to provide them with the knowledge and experience they need to create user-friendly resources.

We're not trained for it. Grad. schools tend to hand us chalk and say, "Now you are a teacher." Most people don't do well with that. (Scientist)

Many members of the OSS E/PO community continue to report that they are unclear about the mission of the OSS E/PO Effort, the role of the SN, and the expectations of those who are developing space science resources.

The difficulty is, it's not clear what we're trying to do. That puts the point on the problem in a nutshell. We're herding cats. Initiatives and directives coming from every which way and everyone thinks they know how we should be doing it better. (Scientist)

Data show little consensus about how to make the best use of the rich resources within the OSS E/PO community. Members of the OSS E/PO Effort reported a growing awareness of the need to develop standards and assessment tools to evaluate the utility of the resources and programs created by the OSS E/PO Effort. There is also a growing awareness of the need for better information about current educational research.

We don't have a credentialing system. You're sort of making it up as you go along. You wouldn't do this in science. [We] need to learn the literature, not reinvent the wheel. (Scientist)

I would never think about doing any type of E/PO activity without reference to the research base. I recommend that you go to that research base . . . Reference things. Move our society to a more academic basis. (Scientist)

One of the underlying assumptions of the OSS E/PO Implementation Plan is that scientists don't need to be experts in educational pedagogy to make an impact. The plan suggests that OSS provide "help in looking for high leverage opportunities, help in arranging partnerships and alliances with educators, help in understanding what is now happening in education and what sorts of materials are appropriate for the classroom, help in removing impediments that get in the way of scientists participating in education and outreach even if an individual wants to do so" (p. 27).

The OSS E/PO Effort has created some very effective resources working in conjunction with organizations such as TERC, Lawrence Hall of Science, and McRel. Such partnerships allow scientists to utilize their content expertise while others, more familiar with current educational research, shape the content into pedagogically sound resources. These partnerships have been a goal of the OSS E/PO Effort from the outset; one component of the system, the network of Broker/Facilitators, is specifically charged to "arrange alliances between educators and scientists."¹³ Expanding these partnerships could benefit the entire system, and ultimately serve to better meet the needs of the end-users.

Collaboration between someone who's an expert in the subject and someone who's an expert at teaching, that's the best way to do it. (Resource developer)

There needs to be a way that scientists can work with established groups to make their input have more leverage. One person doing something can go a long way. It's not hard to contribute to something that's already in place. (Scientist)

What can OSS do to connect with systemic reform groups? Getting the dialogue going is an important start. Perhaps the B/Fs could powwow to talk about how to incorporate them. Next meeting I'd like to see not just us, but also people we can partner with. (SN member)

From the outset, the OSS E/PO Effort has sought to "involve scientists in education and outreach."¹⁴ Through support of education within missions and supplementary research, and by providing recognition for scientists who contribute to E/PO, OSS has increased scientist involvement. OSS can maximize the benefits of this increased involvement by providing systemic, coherent PD to those who wish to contribute to the OSS E/PO Effort.

¹³ *Implementing the Office of Space Science Education/Public Outreach Strategy*, p.27.

¹⁴ *Implementing the Office of Space Science Education/Public Outreach Strategy*, p.15.

INCREASING PERSONAL INTERACTIONS

Many of the individuals who provided data for this report—educators, scientists, and resource developers—said they first became involved with the OSS E/PO Effort, or first began using OSS E/PO resources, as a result of a direct contact from someone within the system. Others said that after using some resources or attending a workshop, they realized they weren't getting all they could from the OSS E/PO Effort, so they took the initiative to find contacts within the system. In general, those who took the time to cultivate these relationships said they were worthwhile. Knowledgeable individuals within the OSS E/PO Effort act as "tour guides," providing assistance in finding relevant resources and integrating them into the learning environment.

I think the program is working so well because of the enthusiasm of [resource person]. Her enthusiasm and continuing being informative with all the people in the program, that's what keeps me coming back. (Teacher)

[Our contact] is doing a good job of making it clear what the requirements are and when they are needed, so you're not surprised. (MUI recipient)

[The program director] has done a great job . . . Keeps us informed, sends us materials to give to the public. Basically, she has kept that excitement going. (Volunteer)

The OSS E/PO Effort has been working to increase interactions among educators, scientists, and resource developers. Such interaction opens lines of communication about the needs of the various populations, who often know little about the constraints under which the others operate.¹⁵ Educators benefit from increased understanding of scientific content, scientists benefit from firsthand experience of how their content knowledge is used and understood in classrooms and museums, and resource developers benefit from learning firsthand what educators need and what space science can provide.

Enhancing Education

The OSS E/PO Effort has increased the number of scientists working in both formal and informal education, and participating in public outreach. Programs like SUNBEAMS and GAVRT bring scientists into contact with teachers and students; many museum and planetarium shows utilize visiting scientists; and ambassador programs bring scientists to the public. Data from audiences who have taken advantage of these programs indicate that personal contact with scientists supports the goals of the OSS E/PO Effort: sharing excitement, enhancing education, and building the 21st century workforce. Both formal and informal educators said that meeting scientists and others working directly with

¹⁵ See the August 2001 evaluation report for further discussion of this issue.

NASA makes science more accessible. This accessibility benefits both educators who have direct contact with the OSS E/PO Effort and the wider audiences that they serve.

I wish they would have more people who would just come out to the schools. It's more exciting to see people doing the work. (Teacher)

I think having scientists [at the museum] transforms people. It gives them a topic of discussion to talk about on their way home. (Museum staff person)

Human contact is cited as especially important by those working within communities that have traditionally been underserved by space science resources, such as inner-city students, minorities, and the differently-abled. Our data suggest that many learners within these communities find space science irrelevant and inaccessible. Personal contact is a powerful tool for making connections to students who are underprepared to learn science.

The Internet doesn't work in [the African-American] community. You need that personal touch. Science is viewed as an aberration. It's a fearful entity in the black community. You need someone to generate the motivational impulse. The kids who are going to find stuff on the Internet, or even watch a TV show, are already motivated. (Scientist)

The B/Fs are charged with developing relationships between OSS and the wider educational community. Personal relationships, trust, and community building are extremely important, but take time. Some B/Fs are leveraging their contacts within the educational communities by developing cadres of education leaders. These leaders may be part of large pre-existing educational networks, which share resources and information, and can act as conduits for OSS E/PO information and resources. Thus, interactions between scientists, members of the OSS E/PO Effort, and educators may lead to dissemination of E/PO resources beyond the individuals involved directly.

Partnering with educators as disseminators can extend the reach of the OSS E/PO Effort in other ways. Some dissemination partners reported that members of their audiences may be intimidated by NASA and OSS personnel, but find fellow educators more accessible. Educators may be more effective than scientists at reaching other educators, especially those who have little familiarity with science and little confidence in their own understanding of the subject.

It's like a grassroots thing. Teachers get intimidated by scientists. The knowledge difference is vast. To be taught by other teachers is less threatening. It's more familiar when you're taught by teachers—you speak the same language. (Teacher)

I thought I was going to be lost because I'm not technologically advanced. I thought I'd be really embarrassed, but it was all just teachers like me. I thought it was going to be a bunch of scientists. (Teacher)

Individuals who are familiar both with the OSS E/PO Effort and with specific audiences are in a good position to help audiences identify appropriate resources and, if necessary, adapt them. By aligning the offerings of the OSS E/PO Effort with the needs of its audiences, these points of contact provide coherence for educators and learners.

Enhancing Resource Development

Teachers, librarians, museum staff, and other consumers of OSS E/PO products are the best judges of what they want and need; their input is invaluable to the resource development process. The OSS E/PO Effort has provided several ways in which educators can contribute to the resource development process. For example, one of the Broker/Facilitators has developed a local Teachers' Advisory committee that meets regularly to discuss teacher needs; some resources are developed by teachers and scientists working in collaboration; the review panels for E/PO funding often include educators and educational administrators.

OSS has created opportunities, such as the OSS Education Conference, to facilitate and encourage communication among resource developers and between developers and users. These opportunities benefit only some members of the OSS E/PO Effort. There is not yet a coherent system for sharing information about what user needs remain unmet. Many resource developers said they receive little input or feedback from users and have relatively limited interaction with E/PO teams from other missions. Thus, they lack good information about what types of resources already exist and what topic areas have few materials to support them. This leads to redundancies and gaps within the array of products developed.

[At the Education Conference] I was sitting at a table with three different people all working on Mars resources, unaware of each other's work, which means there's three Mars products that teachers have to look at to figure out what one to use.
(Teacher)

NASA is notoriously a beast with 18 heads. There were 18 places to find the same image and it was frustrating.
(Small museum staff member)

SUMMARY AND RECOMMENDATIONS

SUMMARY

NASA's OSS E/PO Effort has greatly increased the number and variety of resources available to schools, museums, and the public since the development of the current E/PO Effort. Many of these resources were developed to reach populations that have traditionally been underserved by space science educational materials. Others were designed to reach audiences through new venues, such as presentations in malls, star parties, and installations in public places. Resources have proliferated to the extent that it is nearly impossible to document them all. The range and diversity of opportunities underscore the success of the OSS E/PO Effort; they also signal a systemic challenge.

The OSS E/PO Effort consists of an array of discrete efforts. Each individual mission or program creates resources designed to share its particular areas of space science expertise with a range of audiences. Lack of communication among those developing resources leads to redundancies and gaps across the system. Because resources are generally developed independently of one another, it is difficult to assemble an array of complementary products and activities. Some users report that they are confused and frustrated by the scope of E/PO resources.

In general, those who use these resources are pleased with them. They reported the audiences that *they* work with find OSS materials exciting and engaging, and they trust OSS materials to be accurate and up-to-date. Some educators reported that they are not able to make as much use of OSS E/PO resources as they would like, because the resources are not fully aligned with their needs. Educators reported challenges using resources that do not address national and state standards, resources that do not reflect current pedagogical theory, and resources that require more space, time, and technological equipment than is available in their schools, libraries, or museums. Products and services are not uniformly assessed either before or after delivery. This leads to inconsistency across resources and makes it difficult for users to predict the quality or value of a given product.

There is currently no mechanism for systematically communicating information throughout the OSS E/PO community about user needs or about the goals and strategies of the system. The challenge of implementing a widespread, coherent effort to share information about user needs with all members of the OSS E/PO Effort is complex and ongoing.

The OSS administration has taken a variety of steps to increase scientist participation in E/PO development. These steps include mandating that all missions have an E/PO component, providing funds for E/PO aligned with Supporting Research Grants, using the SN to increase coordination and collaboration across the scientific and educational communities, recognizing contributions to space science education, and providing professional development opportunities for scientists who wish to become involved in E/PO. This has led to an expansion of the number and variety of individuals involved in the OSS E/PO Effort, which in turn has supported the increase in E/PO resources.

OSS has been proactive in fostering partnerships between educational experts and some resource developers, and in providing PD for some of the people creating space science resources. OSS can help maximize the effectiveness of the resources it creates by soliciting more systematic input and feedback from educators and by providing more support and training for resource developers.

RECOMMENDATIONS

START WITH USER NEEDS

From the beginning, the OSS E/PO Effort has said that the audience perspective should be the starting point for resource development, but data suggest that this is not always the case. OSS might consider systematically including audiences in the creation and assessment of new resources in a variety of ways.

- Invite audience members to give periodic feedback on existing products and those under development. This happens in some places throughout the system, but there is not currently a systematic method for soliciting and using audience input.
- Expand the number and scope of sustained relationships between OSS scientists and E/PO personnel and audience members (teachers, volunteer lecturers, museum staff) through ongoing programs such as SUNBEAMS, the Space Science for Illinois Teachers Program, and Solar System Educators. These relationships serve two purposes:
 - They develop cadres of individuals with a strong understanding of space science content, which they can disseminate to a larger population
 - They provide the OSS E/PO system with access to users who can speak articulately about their needs and the needs of their colleagues
- Organize focus groups of educators from the state, district, and school levels to share information about their needs and constraints. This information can inform the development of a framework or action plan for creating more connected sets of resources that can be used in multiple settings.

PROVIDE EDUCATIONAL EXPERTISE

Scientists do not need to be experts in education, but they do need support from individuals who are.

- Expand and formalize partnerships with educational organizations such as TERC and the Lawrence Hall of Science. Allowing individuals within these institutions to provide pedagogical expertise would free scientists and scientist-educators to focus on scientific content.
- Expand the network of education experts through the OSS E/PO Community (within each Forum and possibly within each Broker/Facilitator institution; perhaps with each institution having a specific area of expertise). This network can support all mission personnel who are developing resources.
- Systematize and publicize the PD currently available to scientists who wish to become more educated about pedagogy and current educational theory.

INCREASE COMMUNICATION AND COORDINATION

E/PO staff will be able to better coordinate their efforts and to work collaboratively when they share a common understanding of the program goals and what must be done to accomplish them. This should facilitate the development of an integrated, coherent system of resources, with fewer gaps and redundancies and more complementarity across products. OSS administration might consider taking the following steps to facilitate this coordination.

- Develop and disseminate clear guidelines for the creation of E/PO materials incorporating input from both users and education experts.
- Encourage the development of resources across the system that complement one another and resources that support skills and knowledge developed by existing resources.
- Design a user-friendly method of sharing information about OSS E/PO activities and resources within and beyond the OSS E/PO community. At present, it is difficult for both resource developers and audience members to find information about what products are available, where and when activities will be taking place, and who to contact for information. In part, this is due to resistance from resource developers to using the current tracking systems (see the Phase II evaluation report for an in-depth discussion of this issue).
- Develop a list of themes/topics that users say they want addressed. E/PO developers can use this list as a reference.

The OSS E/PO Effort has made tremendous progress in many directions in the seven years since the Strategic Plan was developed. By building on this progress to create a

rational system that is valuable and accessible to users, the OSS E/PO Effort will ultimately provide a better product to those it is meant to serve.